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nutritive efficiency, and that a "standard" allowance of 1 gram protein per kilogram of body weight per day provides a margin of safety of from 50 to 100% above the minimum amount actually required to maintain equilibrium.

For growth and reproduction the amounts of protein required are relatively larger than for maintenance, and the selection of the protein is also of greater importance.

The data of all of the experiments here considered are summarized, with fuller discussion and with citation of original sources, in a paper which is being offered for publication in the *Journal of Biological Chemistry.*

THE TRANSPLANTING OF SEA ANEMONES BY HERMIT CRABS

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Communicated by H. S. Jennings, November 6, 1919

It is well known that hermit crabs inhabit the vacant shells of molluscs, that as they grow they change from smaller shells to shells of larger size and that hydroids, sea anemones and other animals are frequently attached to these shells. Several observers have reported that they have seen hermit crabs remove sea anemones from their old habitations and transplant them on their new shells. Such observations are mentioned in a few zoölogical text-books but usually the treatment is such as to leave the impression that there is an element of doubt as to the occurrence of the habit. For this reason I shall describe the behavior of individuals belonging to two species of hermit crabs, *Pagurus deformis* and *Pagurus asper*, occurring in the sea about the Philippine Islands, which bear sea anemones on their shells (Dolidae, Strombidae, Cassis, etc.) and which transfer these animals when they change their shells. My observations are worthy of note since they were made in the presence of four co-workers (Dr. L. E. Griffin, Mr. Alvin Seale, Professor A. L. Day and Professor S. F. Light), and since the individuals of the species of hermits mentioned both usually carry two kinds of sea anemones, one, a species whose individuals are large, the other, a species whose individuals are small, the former being fixed, as a rule, on the top of the shell and the latter generally on the under side near the protruding head of the hermit crab.

The following account of the behavior of the hermit crabs and sea anemones with reference to one another is undoubtedly in harmony with what occurs in nature although it deals with observations made in the laboratory: A hermit inhabiting a shell bearing two large sea anemones on the upper surface and a small one in the mouth of the shell was placed in an aquarium containing a clean, empty Dolium shell of a larger size than the one in use. The hermit began to examine the new shell almost immediately, put its pinchers and some of its legs inside of the shell and remained in this position for a considerable length of time. Occasionally the pinchers were moved about and were used apparently to examine the outside of the shell. Then, suddenly, the abdomen was inserted into the new shell and the hermit without moving away grasped one of the large anemones clawing, pinching and pulling it. The anemone instead of contracting as it would if disturbed by the observer remained expanded even though the mauling it received was really very strenuous and although it was frequently jammed up against the newly occupied shell. After these movements had continued at least for ten minutes the base of the anemone began to loosen in several places. Instead of completing its work at once the hermit began to pinch and claw the other large anemone which withdrew its tentacles, soon however protruding them again. Then suddenly the hermit left the second anemone, picked off the small, white one and applied it at the mouth of the new shell almost directly under its own head, where it soon became firmly attached. The crab now attacked again one of the large anemones, removed it easily, turned it round and round between its legs and pinchers and finally pushed the base against the side of the new shell. It failed to become attached, slipped down on the hermit's legs, stuck to them for a moment, dropped off and finally attached itself on the glass bottom of the aquarium. Again the hermit crab seemed to lose interest in the anemone on which it was working and began tugging, pinching and scratching the only remaining anemone attached to its old shell. After a long period of handling and some little prying up of the edges of the base of the anemone, during which time the tentacles contracted completely, the anemone suddenly slipped off apparently of its own accord. (Strange as it may appear the crab seems never to cause any injury although the base of the anemone is very thin and when taken off by man is easily torn.) The hermit now caught the anemone which had just slipped off, rolled it around and around for a few seconds and then with the aid of the hind legs applied the tentacle-side against the shell. Again the anemone slipped off and was disregarded for a moment while the hermit picked up the other anemone. Still holding the latter it lifted up the one that had just slipped off and rolled them both around for some little time. Finally one became attached to the side of the shell by one edge of the base and was left to shift for itself. The other was passed up to the opposite side of the shell with the aid of the posterior legs of the hermit and soon both anemones became firmly attached with their tentacles beautifully expanded. While the actions of this hermit crab were not nearly so accurate as those of some others I have observed, yet like all of them it showed a constant and hurried activity which seemed to indicate that some inherited nervous condition existed which was directing its actions. Furthermore, during the time in which this remarkable behavior was taking place the hermit crab, although at other times reacting quickly to movements outside of the aquarium, showed almost no reaction to the stimuli which are ordinarily produced by people passing or moving in front of the aquarium. This account describes a single series of observations but several other series were made in which the behavior was similar.

It seems probable that the anemones become associated with the hermit crabs very early in life, and that possibly they become attached in larval life to mollusc shells inhabited by hermits.

While the anemones are undoubtedly benefited by their association with the hermit crabs since the latter lead a wandering life in heavy growths of eel grass which harbor many small organisms, and while they may often take morsels from decaying animals upon which the hermits feed, the writer has never seen the hermits transfer pieces of food to the sea anemones as has been described by one investigator.

In the absence of any experimental work on these animals it cannot be proved that the sea anemone affords any protection for the hermit but it seems probable that stinging cells of the former would prevent the hermits being eaten by fishes.

We cannot believe that the hermit crab during its life time has learned by experience that it derives any advantage from transplanting the sea anemone although we know that crabs in general do profit by experience, and yet assuming that the remarkable behavior of the hermit is due to instinct, that is, to an "inherited combination of reflexes" which have been so brought together by the nervous system that the behavior has become fixed and adaptive in the species, it is extremely difficult to conceive how it has come about.

SPECTRA OF EXPLOSIONS

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Communicated by G. E. Hale, December 2, 1919

Some experiments with explosions of fine, iron wires by electrical means have led to the development of a method of producing a brilliant continuous spectrum extending throughout the visible spectrum and as far into the ultra-violet as can be recorded by a quartz spectrograph. On the continuous background appear as absorption lines practically all the iron lines usually found in the arc. For example, in the green region between $\lambda 5150$ and $\lambda 5700$, which is unfavorable for reversals in general, this spectrum on a scale of $6A$ per millimeter shows 128 absorption lines due to iron; Burns' table for the same region contains 215 lines, and